MDA SBIR Draft 15.3 Topics

Topic Number: MDA15-007
Topic Title: Open Framework Planner with Embedded Training
Topic Author: Karla Spriestersbach

Objective: Design an open, modular framework for a missile defense planner such that a training system can be embedded in it, allowing for underlying components to be rapidly inserted (e.g. mapping engines and visualization tools).

Description: The goal of this topic is to investigate and demonstrate the feasibility and utility of building an integrated command and control (C2) planning and training system. While this effort is intended to focus on missile defense (C2), the system must be designed and developed with the intent of expanding to address integrated air and missile defense.

Typically, battle management planners and training systems are separate products; however, both have sub-systems that perform nearly identical functions, to include modeling of current threats and blue force capabilities, visualization and mapping, scenario generation, and scenario execution with record-and-playback capabilities. The unique capabilities for a missile defense battle management planner include defense-design creation and effectiveness analysis while distinctive training system capabilities include truth and instructor displays, red cell controls (during scenario execution), and white cell controls (e.g. script or change blue force failures, degraded performance, and shot doctrine). However, even these unique planner and trainer capabilities would add value to each other in an integrated system.
The desire is for an open, modular, flexible, and adaptable missile defense planner which abstracts the component functionality (including the visualization and mapping engine processes) to facilitate rapid insertion of higher fidelity or quality services. This framework should include a training path which allows for the current planner (at any release) to be used for training and must be consistent with the underlying integrated missile defense planner. It should accommodate new plug-ins for blue force lay downs and red force threats. The framework should also safely separate training from real-time access.

This effort should incorporate innovative methods of product architectural design in order to facilitate the latest data sharing methodologies. This topic is not soliciting visualization. Mapping engines/products already exist and are not a part of this effort.

Phase I: Develop and demonstrate a missile defense planner architectural framework that allows dynamic instantiation of system components and or capabilities, as well as providing simple low-bandwidth methods of data sharing between processes. Demonstrate how this architecture could be used to simplify the evolution of missile defense product development life cycles while not restricting future enhancements.

Phase II: Refine and update concept(s) based on Phase I results and demonstrate the technology in a realistic missile defense environment using government provided visualization and mapping engines. Demonstrate the technology’s ability to interoperate with the current missile defense battle management planning and training environments.

Phase III: Demonstrate the new technologies via operation as part of a complete missile defense system or operation in a system-level test bed to allow for testing and evaluation in realistic scenarios.

Transition technologies developed under this solicitation to relevant missile defense elements directly or through vendors.

Commercialization: The contractor will pursue commercialization of the various technologies and optimization components developed in Phase II for potential commercial and military uses in many areas such as disaster planning/training.

References:

1. D. Miles. June 01, 2011. “Army Chief Discusses Future of Training.” Retrieved from http://www.defense.gov/news/newsarticle.aspx?id=64141.

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3. Joint Publication 5-0. August 11, 2011. “Joint Operation Planning.” Retrieved from http://www.dtic.mil/doctrine/new_pubs/jp5_0.pdf.

4. Missile Defense Agency. May, 2009. Missile Defense Agency (MDA) Exhibit R-2 RDT&E Budget Item Justification. Retrieved from http://comptroller.defense.gov/defbudget/fy2010/budget_justification/pdfs/03_RDT_and_E/Vol_2_MDA/PE-0603896C-C2BMC.pdf.

Keywords: Defense Planning, Architecture, Data Sharing Methodologies

Topic Number: MDA15-009
Topic Title: Irrefutable Tamper Evidence
Topic Author: Hyong Chang

Objective: Develop approaches and technologies that enable irrefutable and unalterable logging and maintaining of tamper events of commercial off-the-shelf (COTS)-based critical technology solutions without utilization of write-once memory.

Description: The proposed research and development project will provide a way to increase confidence levels to determine whether the detected event, in fact, was an infiltration. The application is for systems that do not have write-once memory and its processing capabilities. This irrefutable evidence should not compromise the systems functionality. This topic is not seeking solutions that use tamper-evident labels or security seals. Though the particular solution may be tailored for individual applications, the concept and methodology of the solution should be applicable to various COTS and military hardware. Preferred solutions should work without introducing additional performance risks or costs to the weapon platform and its mission. Additionally, focus on minimal impact to system availability and maintainability.

Phase I: Research and develop methodologies for proof-of-concept on a representative system that has multiple protections other than this irrefutable evidence of event detection technology. The purpose should be to demonstrate the feasibility, uniqueness, and robustness of the protection that the proposed technology will offer. Estimate the performance impact.

Phase II: Based on the Phase I research; develop, demonstrate and validate a prototype of the developed methodologies or techniques on a representative weapon platform. Conduct an analysis to evaluate the ability of the technology's functional effectiveness in a real-world situation. The contractor should also identify any anticipated commercial benefit or application opportunities of the innovation.

Phase III: Integrate the developed technology into a system application, for a system level test-bed. This phase will demonstrate the application to one or more military systems, subsystems, or components — as well as the product's utility against industrial espionage. Conduct an analysis to evaluate the performance of the technology/technique in a real-world situation. For transition, consider a partnership with a current or potential supplier of missile defense systems, subsystems, or components.

Commercialization: The proposals should show how the innovation can benefit commercial business or that the innovation has benefits to both commercial and defense applications. The projected benefits of the innovation to commercial applications should be clear, whether they improve security, reduce cost, or improve the producibility or performance of products that utilize the innovative technology.

References:
1. General resources on Department of Defense Anti-Tamper: https://at.dod.mil.

2. General resources on tamper-evident technology: http://en.wikipedia.org/wiki/Tamper-evident_technology.

3. Scott A. Crosby and Dan S. Wallach. 2009. "Proceedings of the 18th conference on USENIX security symposium" - Efficient data structures for tamper-evident logging, http://dl.acm.org/citation.cfm?id=1855768&picked=prox&cfid=607596521&cftoken=29246816.

Keywords: Technology Protection, IP Protection, Tamper Evidence, Forensic Investigation

Topic Number: MDA15-011
Topic Title: Self-Building/Establishing Networks
Topic Author: Krist Norlander

Objective: Develop and implement an innovative hardware and/or software solution that, in response to user or system command, can detect and identify electronic network (wired and/or wireless) infrastructure components, employ state of the art methods and technologies to automatically or under human-in-the-loop control configure the network components, and test/monitor the viability of the components to satisfy a predefined network architecture definition.

Description: The missile defense modeling and simulation mission and test infrastructure may benefit from the development of a self-establishing network capability. Such a capability will enable the autonomous establishment and maintenance of network connections by a primary network control node between remote components of a simulation or test according to a pre-defined network architecture.

The capability developed under this topic should incorporate innovative networking technologies to create a new autonomous networking capability. While other networking capabilities such as the Self-Organizing Networks (SONs) used in modern ad-hoc mobile and sensor networks utilize some autonomous connectivity and configuration capabilities, which may be leveraged in the development of this research, this topic differs in that the networking capability designed will create networks which will be established from a single control node with architectures that are defined by the user at the time of build, may be unique from build to build, may be re-defined and re-built according to user specifications, and which conform to DoD Cyber Security protocols. These requirements necessitate an entirely new capability which will require new research to develop and implement.

The research performed under this topic will identify the external network nodes that can be exploited to expand the network to meet the architecture topology. The network control node initiates control commands to configure the external nodes to meet the specified architecture parameter definitions. The control node also autonomously monitors the network and rebuilds or reconfigures the network when sub-components no longer meet the architecture parameter definitions or when desired changes to existing network architectures are specified by the user, and provides reports on the health and status of the network. Additionally, it provides for user oversight, management, intervention, and override of autonomous networking operations at all stages to ensure user control of autonomous networking and security activities. Upon completion of the network expansion and configuration, the control node then provides results of the network build and compliance with the architecture definitions.
Phase I: Develop a design product which will present a notional architecture to be pursued in creating a hardware and/or software solution providing a self-establishing network capability which conforms to the user-specified network architecture and security constraint. The design will capture the key areas where new development is needed, suggest appropriate methods and technologies to realize the design based on the research performed, and incorporate new technologies researched during design development. Develop a plan for verification and validation (V&V) of the design once built.

The results of this phase will provide recommendations for what is needed to fully meet the architectural definition described above and identify where gaps exist. The proposed network design will also comply with DoD Cyber Security protocols, ensuring that network connections are only formed between authorized nodes at the same level of information security, that those connections pass data securely, and that tools are in place for the autonomous detection and mitigation of security breaches.

Phase II: Using the design developed in Phase I, produce a small-scale prototype self-establishing network capability which can be used for test & evaluation of the basic networking and cyber security components of the design and identify areas where new development is needed. Develop new hardware and/or software technologies to support the prototype design proposed in Phase I. Perform V&V of the prototype according to the plan developed in Phase I to ensure that the priority objectives are adequately met. This prototype work will be used to inform the development and implementation of a mature, full-scale capability in Phase III.

Phase III: Scale-up the self-establishing network capability from the prototype utilizing the new hardware and/or software technologies developed in Phase II into a mature, fieldable capability. Develop an interface to provide the user with reports of the completeness of network builds and compliance with the user-defined network architecture and cyber security protocols, and facilitate user oversight, management, intervention, and override of the system when necessary. Deploy the fully tested, verified, and validated capability.

The contractor will commercialize the Phase III hardware and/or software, enabling an autonomous establishment or re-configuration of a wired and/or wireless network in accordance with a user-defined network architecture and adhering to user-defined network and cyber security preferences and/or protocols (desired security options may be selectable by the commercial user). Such autonomously configured networks will adhere to and provide for user oversight, management, intervention, and override of autonomous networking operations at all stages of operation. This innovative technology will support increased speed and ease of secure network building and management in the private sector as well as secure business system integration.

Commercialization: This innovation technology for the autonomous establishment of secure networks has clear application beyond the scope of DoD systems. This technology can be applied to modems, routers, switches, hubs, protocol standards, ISO standards, IEEE standards, etc.

References:
1. Sengul Cigdem, Aline Carneiro Viana, and Artur Ziviani. 2012. "A survey of adaptive services to cope with dynamics in wireless self-organizing networks." ACM Computing Surveys (CSUR) 44.4: 23. https://radar.brookes.ac.uk/radar/file/36e91d15-6724-e0dd-cef8-da4bb6f125c3/1/SurveyonAdaptiveServices.pdf.

2. Honglin Hu, et al. 2010. "Self-configuration and self-optimization for LTE networks." Communications magazine, IEEE 48.2: 94-100. Retreived from http://www.signal.uu.se/Publications/pdf/p1002.pdf.

3. D. Pace. February 2004. “Modeling and Simulation Verification and Validation Challenges.” Johns Hopkins APL Technical Digest, Volume 25. Retreived from http://techdigest.jhuapl.edu/TD/td2502/Pace.pdf.

Keywords: Self-Establishing Network, Systems Integration Tool, User-Defined Architecture

<u>Topic Number</u>: MDA15-012
<u>Topic Title</u>: Inline Threat Generation for Modeling and Simulation
<u>Topic Author</u>: James Ceney

<u>Objective</u>: Elicit new and innovative approaches to perform inline threat generation (ITG) in a constructive digital simulation, without having to pre-generate the threat data, in order to stimulate modeling and simulation (M&S) used for missile defense performance assessment.

<u>Description</u>: High-fidelity, constructive digital simulations are used to assess the performance of missile defense at the element and system level. Pre-scripted input files consisting of high-fidelity data that effectively portray the kinematics, signatures and lethality-related traits of red force missiles in a "truth" sense, stimulate various models so that the truth inputs are appropriately "perceived" by the missile defense element models and simulations during simulation runtime. There are currently no processes, tools, or software that can generate the necessary detailed high resolution truth data "inline" during runtime of a constructive digital simulation.

New innovative technologies are needed that will enable ITG in these high-fidelity constructive simulations. This innovative capability would enhance the credibility of simulations in the M&S Enterprise, shorten integration time (enabling efficiency gains and reducing event schedules), produce greater quantities of quality, credible decision quality data, and expand the envelope of behaviors assessed via M&S by allowing red forces to react and change "inline" based on what is occurring on the simulation "gameboard" during runtime. If successful, the approaches developed under this effort could be applied to the problem of producing similar truth data for blue force interceptor flyouts.

Input data considerations: The ITG capability should be able to take as inputs the minimal set of parameters and inputs that are currently used for offline, pre-scripted threat generation tools, as well as any parameters that may be required for simulated responsive behavior of the threat object that could not have been predicted priori. This input data would include both "scenario independent" missile and signature characterization/data from the Intel community and other threat authorities, as well as "scenario specific" parameters about any and all particular missile flyouts in any given scenario.

Runtime considerations: The slower a simulations runs, the less the assessment data that is available. The inline threat approach being investigated here would presumably shift the time investment of threat data production from "pre-execution" to "in-execution". The end-state desire would be that, when rolled up, this shift in where and when threat data is generated would be a net positive in terms of impacts to simulation employment timelines, as compared to the legacy, pre-scripted approach. In other words, we do not want inline threat generation to so "bog down" the runtime performance of the overall simulation that, in the end, the simulation employment timeline would have been better off to have stayed with pre-scripted threats. To that end, also note that the use of the word "inline" does not mean that leveraging of already pre-existing threat data, at least as a point of departure during runtime, for example, is necessarily prohibited.

V&V considerations: "Offline" threat tools and their outputs are rigorously validated and verified as "standalone" modeling software and are used to create pre-scripted threat data. Information provided by the appropriate authorities in the Intel and threat communities validate these missile models and corresponding signatures.   An inline threat capability needs to adopt and apply the same rigor and processes that the credibility of threat data created by ITG is similarly unimpeachable. It may seem obvious or a truism to say that software tools should be verified and validated; however, it is highlighted here as a special concern and emphasis area for the use of M&S for performance assessment.

Phase I: Develop a proof-of concept prototype/demonstration of the ITG approach, including a simulation conceptual model and top-level architecture of how a high-resolution ITG capability would be integrated into a system-of-systems simulation comparable or traceable to a simulation. Demonstrate approaches to verification and validation of the ITG. Proof-of-concept for this phase may be related to unclassified surrogate red force and blue force models or other systems, or options for a stand-in for the overarching simulation could be provided GFE. The Phase I effort could be appropriately scoped to an initial subset of inline threat data production demonstration versus the entire threat data package. Provide an initial CONOPS for V&V of the inline threat tool. Demonstrate initial capability for truth interaction of threat data creation, i.e. modification or creation of threat data during runtime in reaction to truth data that emerges on the runtime "gameboard", in a way that could not have been pre-scripted and was not explicitly part of the user input parameters.

Phase II: Using the conceptual model and insights gained from the Phase I prototype, develop a working ITG, encompassing a capability to generate inline all types and amounts of threat data currently developed today for performance assessment simulation. Major emphasis of Phase II would then be on a rigorous V&V demonstration and benchmarking against an analogous legacy set of threat generation capabilities.

Phase III: Deploy working ITG capability within missile defense applications. Develop operational interfaces with existing simulation tool sets. Update the ITG to keep pace with adversary data and threat models needed for current-day simulation efforts. Support all activities for endorsement/accreditation of the ITG capability leading to accreditation by the appropriate authorities. Ensure that design encompasses modularity (i.e. upgradeability) and usability, such that keeping pace with operational threat changes does not entail massive ITG development efforts and code changes, but rather input parameter changes, with documentation via conceptual model, specifications and user instruction, per M&S development best practices. Investigate expansion of ITG capability to also encompass blue force interceptor truth data generation.

Commercialization: The technology developed here could tie into commercial opportunities related to high-speed computing as related to simulation of complex systems-of-systems.

References:
1. Missile Defense Agency. Undated. Trajectory Generator External (TGx) product factsheet. Retreived from http://mda.info@mda.mil.

2. Analytical Graphics, Inc. Undated. AGI Missile Modeling Tools product factsheet. Retreived from http://www.agi.com/downloads/products/product-literature/mmt_flyer.pdf.

3. Robinson. April 2010. "Conceptual Modeling: Who Needs It?" SCS M&S Magazine.

Keywords: Simulation, Missile Modeling, Missile Signatures, High-Speed Computing

Topic Number: MDA15-013
Topic Title: Innovative Ways to Shorten System Level Simulation Integration Time
Topic Author: Shawn Sloan

Objective: Provide the government with a set of capabilities that significantly reduces the time and effort associated with integrating complex system simulations.

Description: As missile defense simulations become more complex, integration efforts also become increasingly more complex, resulting in significantly increased software integration times. Further increased software complexities are present within a distributed simulation enterprise. Missile defense simulations would benefit from new and innovative advances in technology and processes in order to shorten system-level-simulation integration time.

The capabilities developed under this topic should incorporate innovative software development technologies to create a robust set of enterprise-level tools and techniques to overcome system-level integration challenges. While traditional software and hardware development technologies focus on integration challenges within one team or sets of teams, this topic seeks to address the challenges associated with multi-organizational, enterprise-wide sets of system integration challenges. These requirements necessitate an entirely new way of accomplishing system level integration of simulations. To accomplish this, new research in enterprise level integration solutions are required.

Research and technology focus areas include:

- Methods to shorten integration time by identifying and mitigating integration bottlenecks
- Increasing software development efficiencies associated with complex system integrations
- Increasing effectiveness of cross-organizational simulation development and integration

Phase I: Develop a design and a concept of operations. The design will capture the key areas where new development is needed, suggest appropriate methods and technologies to realize the design based on the research performed, and incorporate new technologies researched during design development. The contractor should identify the strengths/weaknesses associated with different solutions, methods and concepts.

Phase II: Based upon the findings from Phase I, the contractor will complete a detailed prototype design incorporating government performance requirements. The contractor will coordinate with the government during prototype design and development to ensure that the delivered products will be relevant to ongoing and planned missile defense projects. This prototype design will be used to form the development and implementation of a mature, full-scale capability in Phase III.

Phase III: Scale-up the capability from the prototype utilizing the new hardware and/or software technologies developed in Phase II into a mature, fieldable capability. Deploy the fully tested, verified, and validated missile defense capability.

Commercialization: The proposals should show how the innovation has benefits to both commercial and defense applications. The projected benefits of the innovation should be clear, whether they improve development time, reduce cost, or improve the producibility or performance of products that utilize the innovative technology. This technology could be leveraged in industries where increasingly complex systems are built and tested in a distributed fashion. Examples include automotive industries, NASA, and other aerospace industries.

References:

1.Teldyne Brown Engineering. Undated. “Objective Simulation Framework.” Retreived from https://www.tbe.com/missionsystems/objective-simulation-framework-osf.

2. Missile Defense Agency. Undated. Detailed information and Fact Sheets about MDA and the BMDS. Retreived from http://www.mda.mil.

3. Wikipedia. Undated. “Test Automation.” Retreived from http://en.wikipedia.org/wiki/test_automation.

Keywords: System of Systems Simulations, Software Integration, Software Development Testing, Network Testing, Simulation Testing, Distributed Test Assets

Topic Number: MDA15-015
Topic Title: High Power Fiber Laser Tap Couplers for Phase and Polarization Control
Topic Author: Anthony Sanchez

Objective: Develop innovative, bi-directional fiber laser/amplifier output tap couplers for use in high power fiber laser weapon systems, extending the efficiency, reliability and power handling beyond 1kW per channel.

Description: High energy lasers are required for a number of military applications including long range sensing, target designation and illumination and missile defense. Electric lasers are considered the laser of choice in the long-term since the energy supply is rechargeable and clean. The preferred type of electric laser is the semiconductor diode-pumped fiber laser or amplifier, which integrates well with other sensors and electro-optic elements in an aerospace environment. This topic seeks proposals for demonstration of concepts and hardware which would enable high-brightness, high-power scaling of fiber lasers/amplifiers.

High power fiber optic tap couplers are needed to monitor and control optical amplifier output power, phase, path-length and polarization of double clad gain fibers in all-fiber optical amplifier configurations. For non-polarization maintaining gain fiber operated in a linearly polarized output architecture, it is necessary to pick-off a small amount of amplified output signal for feedback to a control loop that can adjust the input polarization state to yield a linearly polarized output state. High power capable fiber optic tap couplers are required for the development and maturation of co-directional and counter-direcitonal pumped all-fiber architectures to increase ruggedness and reliability for combined power scaling. The ideal tap coupler minimizes loss for the throughput signal for efficiency and power handling capability while picking-off a small amount of signal for closed loop control of polarization, phase and path length matching for coherent beam combining.

Spectrally combined fiber amplifier systems do not require phase and path length matching but do require linearly polarized output for efficient beam combining. High power capable fiber tap couplers compatible with large mode area double clad fibers, polarization maintaining, and non- polarization maintaining fibers are needed. Additionly, tap couplers for photonic crystal fibers and photonic band gap are needed. Fiber tap coupler designs are targeted for lasing of Ytterbium ~1064nm and Thulium ~2000nm. Optical efficiency of the tap coupler, power handling and bi-directionality will be used as metrics for all phases.

Phase I: Deliver a design for a kilowatt capable fiber optic tap coupler and packaging for large mode area Ytterbium and Thulium doped double clad fiber. Criteria for the design includes, bi-directional power handling capability, polarization, phase and pathlength pick-off with robust packaging. Designs compatible with photonic crystal and photonic band gap gain fibers are also sought.

Phase II: Based on Phase I designs and models; build, test, and demonstrate multi-kW capable bi-directional prototype fiber optic tap couplers and conduct in-depth characterization of hardware to show a maturity of technology toward potential commercial and military applications. Deliver packaged devices to solicitor designated government labs for high power evaluation.

Phase III: Demonstrate multi-kW capable bi-directional prototype fiber optic tap couplers packaged for insertion into militarily relevant fiber laser weapons systems. Team with missile defense integrators to demonstrate maturity and technical readiness in military environments.

Commercialization: High power handling optical fiber tap couplers enable fabrication of compact and reliable fiber laser technologies for immediate insertion into military systems. Industrial commerical applications include materials marking, cutting and welding for a wide array of automated manufacturing. In a rapidly emerging medical application, tattoo removal is also an area where all-fiber optical power monitoring and control is needed.

References:

1. F. Gonthier. 2005. "All-Fiber Pump Coupling Techniques for Double-Clad Fiber Amplifiers." Lasers and Electro-Optics Europe. CLEO/Europe:2005 Conference: 716-716.

2. F. Gonthier et al. 2004. "High-Power All-Fiber Components: The Missing Link for High-Power Fiber Lasers." Proc. SPIE 5335.

3. C. Headley et al. 2005.   "Tapered Fiber Bundles for Combining Laser Pumps," Proc. SPIE 5709: 263-272.

4. A. Wetter et al. 2007. "Tapered Fused-Bundle Splitter Capable of 1 kW CW Operation." Proc. SPIE 6453, 64530I.

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6. D. Sipes, et al. February 9, 2012. "Advanced components for multi-kW fiber lasers." Proc. SPIE 8237, Fiber Lasers IX: Technology, Systems, and Applications, 82370P.

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Keywords: High Power Fiber Tap Coupler, High Power All Fiber Pick-Off, Double Clad Fiber Pick-Off

Topic Number: MDA15-016
Topic Title: General Wave-Optics Based Scaling Laws for Multiple/Obscured Apertures
Topic Author: Mark Spencer

Objective: Develop the scaling law capabilities needed to obtain high fidelity solutions and model laser systems that contain multiple/obscured apertures.

Description: High energy laser (HEL) systems with spatially distributed architectures offer the potential for substantially reduced volume while mitigating thermal management requirements at the laser source (i.e., offers the potential for distributed thermal management). This beam combining method uses multiple lasers spatially distributed across the beam director's entrance pupil. The approach also uses inexpensive high bandwidth electro-optic modulators and positioners to control the piston, tip, and tilt of each optical beamlet train, allowing for the overall system to apply a wavefront correction (without the use of combining elements or deformable mirrors) so that the beamlets coherently combine at the target. Current commercially available scaling law modeling and simulation packages, such as SHARE or HELEEOS, do not have the capabilities needed to obtain high-fidelity solutions and model HEL systems that contain multiple/obscured apertures. Scaling law modeling and simulations with these capabilities are sought to enable trade space analyses to be performed to determine the technical viability of the spatially distributed aperture HEL system approach as an alternative to current technical approaches for missile defense applications.

Phase I: Develop a scaling law model for HEL systems that are composed of either multiple apertures that are spatially distributed and/or a single aperture that is obscured. Demonstrate the model adequately addresses critical/key system engineering design constraints (e.g., diffraction, jitter, aero-optic disturbances, atmospheric propagation, beam control, radiometry, etc.) for the selected approach(es).

Phase II: Using the model developed in Phase I, develop packaged modules that are user friendly with proper documentation and have the potential to be implemented in current commercially available scaling law packages such as SHARE or HELEEOS. When needed, validation experiments should be used to reduce risk of model uncertainty.

Phase III: Use the modules developed in Phase II to perform solicitor selected trade studies. Develop a more convenient way of defining different HEL system configurations and advance methods for bookkeeping the power lost to different HEL system configurations.

Commercialization: The new scaling law packages will provide military and commmercial HEL system developers the ability to compare different systems (e.g., end-to-end systems with beam directors that are off-axis unobscured, centrally obscured, spatially distributed with multiple subapertures, and/or conformal phased arrays) and to trade-space analysis necessary for effective planning and decision making.

References:

1. G. A. Perram, S. J. Cusumano, R. L. Hengehold, and S. T. Fiorino. 2010. "An Introduction to Laser Weapon Systems." Directed Energy Professional Society.

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12. N. R. Van Zandt, S. T. Fiorino, and K. J. Keefer. 2013. "Enhanced, fast-running scaling law model of thermal blooming and turbulence effects on high energy laser propagation." Opt. Exp. 21: 14789-14798.

Keywords: High Energy Lasers, Modeling And Simulation, Scaling Laws, Scaling Codes, Beam Control, Wave Optics, Beam Combination, Fiber Lasers

Topic Number: MDA15-019
Topic Title: Smart Readout Integrated Circuit for Dual Band Infrared Focal Plane Arrays
Topic Author: Ping Hagler

Objective: Obtain innovative infrared (IR) readout integrated circuit (ROIC) technology, including digital and three dimensional (3-D) ROICs that will enable large format, high sensitivity, high resolution, large dynamic range, large field of view (FOV), and fast data rate dual-band IR focal plane arrays (FPAs) for missile defense applications.

Description: The long read time and limited data-rate and dynamic-range capabilities of analog ROICs limit sensor performance. Analog ROIC output signal is susceptible to noise requiring added shielding and additional electronics for subsequent signal processing. Digital readout integrated circuits (DROICs) using in-pixel processing and an all-digital readout can provide low noise, wide dynamic range, wide FOV, high resolution, and fast readout rate for overcoming limits imposed by readout circuits on sensors. With the emergence of through-silicon via 3-D packaging and 3-D stacked fabrication technology a future ROIC is capable of more processing on the imager chip creating the potential for smaller, low power systems. Innovative technical solutions are solicited for a ROIC architecture/design that meets the following goals: format 512 x 512 or larger; pixel pitch from 10 micrometers to 30 micrometers; operating temperature 60 - 90 Kelvin; bias range 0 - 1 Volt; detector bias resolution less than 5 millivolts; equivalent well capacity up to 50 million electrons; read noise less than 200 electrons; dynamic range 14-22 bits; full frame rate up to 200 Hz; power consumption less than 300 mW; and matching detector quantum efficiency 45 - 70%. The proposed solutions should also include a design that mitigates the effect of harsh man-made and natural radiation environments, including high energy particles and photons to prevent catastrophic system failure.

Phase I: Develop a preliminary design for the proposed algorithms and electronics architectures. Modeling, simulation, and analysis of the design must be presented to demonstrate clearly how near-term goals will be met. Proof-of-concept hardware development and test is highly desirable. Proof-of-concept demonstration may be subscale or specific risk reduction activities associated with critical components or technologies. Preliminary experimental results can be used in conjunction with modeling and simulation to verify scaling laws and feasibility.

Phase II: Finalize the design of a prototype ROIC including all supporting modeling, simulation, and analysis. Validate the feasibility of the proposed technology developed in Phase I by development of the prototype and demonstration of a ROIC-enabled FPA for characterization testing at a dual-band level. Environmental testing, including radiation testing, is highly desirable in this phase.

Phase III: Develop and execute a plan to market and manufacture the product developed in Phase II. DROIC designers are encouraged to collaborate with the detector and FPA community to achieve the best overall performance of the sensor chip assembly for missile defense applications and enable integration of the FPA into suitable integrated detector/cooler assemblies for subsequent testing.

Commercialization: The contractor will pursue commercialization of the various technologies and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as law enforcement surveillance, astronomy, weather monitoring, aviation collision avoidance sensors, medical uses, homeland defense applications, and other infrared detection and imaging applications.

References:
1. Office of the U. S. Secretary of Defense. February 2010. "Ballistic Missile Defense Review."

2. Brian Tyrrell et al. November 2009. “Time Delay Integration and In-Pixel Spatiotemporal Filtering Using a Nanoscale Digital CMOS Focal Plane.” IEEE Transactions on Electron Devices, Vol. 56, No. 11.

3. 2011. “Effective readout pixel sensor circuit design for infrared focal plane array and three-dimension image MEMS VLSI system.” IEEE, SoC Design Conference (ISOCC): 286 – 289.

4. 2009. “Noise analysis and comparison of analog and digital readout integrated circuits for infrared focal plane arrays.” Information Sciences and Systems. CISS 2009. 43rd Annual Conference: 695 – 700.

Keywords: Readout Integrated Circuit, Digital ROIC, Digitization Per Column, Radiation-Hardened ROIC and FPA, Large Format, DROIC-Enabled FPAs, Digital ROIC (DROIC,Multiple Spectral Band)

Topic Number: MDA15-021
Topic Title: Advanced Reserve Battery Technologies
Topic Author: Kevin Krueger

Objective: Seek innovative solutions to improve performance of the next generation reserve batteries. Improvements should allow for geometric flexibility of batteries, increased energy density, longer shelf life, and manufacturability.

Description: Currently, a variety of reserve batteries power missile defense applications. These power systems have specific requirements that include a long shelf life (up to 20 years), high voltage levels (>100V in some cases), high power density, high energy density, safety, and reliability. Examples include thermal batteries and lithium oxyhalide. Current thermal batteries can achieve peak specific powers greater than 10kW/kg and specific energies greater than 125Whr/kg at the battery level. Similarly, lithium oxyhalide batteries can achieve peak specific powers greater than 2kW/kg and specific energies greater than 250Whr/kg at the battery level.

Future missile defense applications are projected to require more power and longer runtimes in smaller spaces, which will necessitate greater power density and energy density. Technologies that increase operating time or reduce size and weight are desired. In addition, current reserve batteries are geometrically constrained. Missile defense applications seek battery technologies that could enable a more conformal shape in order to achieve a higher volumetric energy density. The proposer could achieve improvements through enhanced packaging efficiency, materials, or electrolytes.

Focus areas for manufacturability enhancements include improved processes for materials, assembly, inspection, quality control, and modeling. Seek manufacturing processes that allow scalability with minimal design changes of the new battery technology. Designs should allow for electrical verification testing of the battery and periodic health monitoring throughout the battery shelf life.

Phase I: Complete an initial design for the battery technology to demonstrate the proof of concept. Include laboratory experimentation and/or modeling to verify the proposed concept. Deliver an initial design for the prototype along with performance estimates.

Phase II: Complete a detailed prototype design and construct a prototype for testing in a simulated environment. Testing should verify design assumptions and performance estimates. Include a detailed design and detailed performance analysis from the prototype testing.

Phase III: Work with missile defense integrator to refine requirements and demonstrate the technology in a relevant environment. A successful Phase III would transition the technology into a missile defense application.

Commercialization: Pursue commercialization in both DoD and non-DoD applications. Reserve batteries have uses in other military and commercial applications including guided munitions, launch systems, and single use emergency systems.

References:

1. Missile Defense Agency. Undated. Overview of missile defense systems. Retreived from http://www.mda.mil.

2. T.B. Reddy. 2011. "Linden's Handbook of Batteries, 4th Edition." McGraw-Hill.

3. Office of Scientific and Technical Information. Undated. Link to documents with information on battery technology. Retreived from http://www.osti.gov.

4. Department of Defense. Undated. Link to documents with some information on some BMD near-term and long-term capabilities. Retreived from http://www.defense.gov/bmdr.

Keywords: Reserve Batteries, Packaging Efficiency, Energy Density, Power Density, Shelf Life, Manufacturability

Topic Number: MDA15-026
Topic Title: MEMS IMU Solutions for Missile Defense Applications
Topic Author: Jeb Buck

Objective: Develop accelerometers, gyros, and inertial measurement units (IMUs), based on micro-electro-mechanical systems (MEMS) technologies capable of performing under missile defense application shock and vibration environments.

Description: Gyroscopes and accelerometers employed in missile defense IMU applications encounter severe shock and vibration during storage, transport, launch, staging, deployment, and engagement. In addition, IMUs in flight systems (interceptors, airborne platforms, and space assets) are constrained by limits on size, weight, power and cost (SWaP-C) while requiring high performance. Current state-of-the-art tactical IMUs utilize optical technology (ring laser gyros and fiber optic gyros) which can be sensitive to temperature, shock and vibration. MEMS technology promise to offer smaller, lighter, and less expensive to produce IMUs than optical systems since integrated circuit manufacturing production techniques are utilized in MEMS fabrication. However, MEMS based IMUs have been known to experience performance degradation while operating through stressing shock and vibration environments. Proposed MEMS solutions should focus on producing reliable, durable, and accurate components that operate without performance degradation under all shock and vibration environments encountered by flight systems. Current industry standard tactical IMUs (e.g. LN-200 FOG and HG1700 IMUs) provide baseline SWaP and performance standards for any proposed effort.

Also, applicable portions of Department of Defense document MIL-STD-810, Environmental Engineering Considerations and Laboratory Tests, and the Air Force Space Command and Space and Missile Systems Center document SMC-S-016, Test Requirements for Launch, Upper-Stage and Space Vehicles, may serve as useful guides for the testing.

In addition to typical accelerometer and gyro performance values used to quantify performance, two performance ranges should be considered. The first is the shock response spectrum amplitude (g) versus frequency (Hz) range and, the second, for vibration, is the power spectral densities (g^2/Hz) versus frequency (Hz) range.

Phase I: Conduct experimental and/or modeling efforts to demonstrate proof-of-principle of the proposed technology to operate in high shock and vibration environments. Demonstrate the technological ability to maintain performance standards in realistic environments.

Phase II: Build and demonstrate the functionality of a MEMS prototype and its ability to be utilized for missile defense accelerometer, gyro, and IMU applications. Demonstrate applicability to both selected military and commercial applications.

Phase III: The cost avoidance realized by employing this technology would be significant. Hence, the anticipated Phase III program customers would include a wide range of current weapon system programs. During this phase, the effort calls for engineering and development, test and evaluation, and hardware qualification.

Commercialization: The proposed technology would be anticipated to have a high level of interest for the aerospace and testing industries where ever accelerometers and/or gyros are practical.

References:
1. Northrop Grumman. 2013. "LN-200 FOG Family Advanced Airborne IMU/AHRS." Retreived from http://www.northropgrumman.com/Capabilities/LN200FOG/Documents/ln200.pdf.

2. Honeywell. 2012. "Inertial Measurement Units." Retreived from http://aerospace.honeywell.com/en/products/communication-nav-and-surveillance/inertial-navigation/defense-navigation/inertial-measurement-units/hg1700.

3. Department of Defense. Undated. MIL-STD-810, Environmental Engineering Considerations and Laboratory Tests.

4. Air Force Space Command and Space and Missile Systems Center document SMC-S-016. Undated. Test Requirements for Launch, Upper-Stage and Space Vehicles.

Keywords: MEMS, IMU, Accelerometer, Gyro

Topic Number: MDA15-027
Topic Title: Lithium Oxyhalide Battery Separator Material
Topic Author: Joseph Gray

Objective: Develop innovative concepts and materials to replace the Polytetrafluoroethylene (PTFE) micro-porous separator and glass separator used in lithium oxyhalide batteries, while maintaining or exceeding performance, decreasing manufacturing complexity, and yield more efficient battery geometries.

Description: The anodes and cathodes of the lithium oxyhalide reserve battery's cells are separated by a PTFE micro-porous material and glass material that provides electrical isolation for the electrodes. The solutions must include producible materials that maximize volumetric efficiency for electrolyte capacity and are optimized for efficient electrolyte flow and distribution upon battery activation. The solutions must utilize materials which are chemically compatible with electrolyte and reaction products after activation.

These efforts will focus on specific military aeropsapce requirements and chemistry while concepts and materials developed in this effort could be integrated into other military systems and aerospace batteries of similar chemistry and have potential for application in other battery chemistries using liquid electrolyte.

Phase I: Conduct experimental and/or modeling efforts to demonstrate proof-of-principle of the proposed technology to operate in the aerospace battery electrochemical environment. Demonstrate the technological ability to maintain performance standards at the cell level.

Phase II: Build and demonstrate the functionality of a separator prototype and its ability to be utilized in a missile defense reserve battery. Demonstrate applicability to both selected military and commercial applications.

Phase III: The cost avoidance by employing this technology would be significant. Hence, the anticipated Phase III program customers would include a wide range of current weapon system programs. During this phase, the effort calls for engineering and development, test and evaluation, and hardware qualification.

Commercialization: The proposed technology would be anticipated to have a high level of interest for the aerospace, marine, and automotive industries and anywhere batteries are used as a primary power source.

References:
1. Superior Technical Ceramics. Undated. "Solid Oxide Fuel Cells." Retreived from http://www.ceramics.net/industries-we-serve/solid-oxide-fuel-cells.

2. Eagle Piche. Undated. "Lithium Oxyhalide." Retreived from http://www.eaglepicher.com/technologies/battery-power/lithium-oxyhalide.

Keywords: Battery, Lithium Oxyhalide, Electrolyte, Ceramic, Battery, Micro-Porous Separator